COSEWIC
Assessment and Status Report

on the

Crooked-stem Aster
Symphyotrichum prenanthoides

in Canada

SPECIAL CONCERN
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – November 2012

Common name
Crooked-stem Aster

Scientific name
Symphyotrichum prenanthoides

Status
Special Concern

Reason for designation
This perennial aster is restricted in Canada to a small area of the Carolinian forest near the shore of Lake Erie in Ontario. The species has experienced historic declines, but no recent losses have been documented and overall numbers appear to be stable. Invasive plants occur at a number of sites and have the potential to negatively impact the species in the future. Additional threats include indirect impacts of Emerald Ash Borer and roadside maintenance. The species has a restricted distribution in Canada, and its persistence will likely require ongoing monitoring and management of invasive species.

Occurrence
Ontario

Status history
Designated Special Concern in April 1999. Status re-examined and designated Threatened in May 2002. Status re-examined and designated Special Concern in November 2012.

COSEWIC
Executive Summary

Crooked-stem Aster
Symphyotrichum prenanthoides

Wildlife Species Description and Significance

Crooked-stem Aster (*Symphyotrichum prenanthoides*) is a perennial wildflower up to 90 cm tall with pale blue flower heads and zigzagging stems. The leaves become narrowed in the lower third but expand at the base to clasp the stem. The species grows in colonies, with multiple stems arising from creeping rhizomes (horizontal underground stems). Each flower head consists of a yellow disc, surrounded by 17 to 30, pale blue rays. Canadian populations of Crooked-stem Aster occur in the Carolinian Forest Region at the northern limit of the species' range. They may be genetically isolated from other populations and have unique adaptations that contribute to their significance for conservation.

Distribution

Crooked-stem Aster occurs in Ontario and in the U.S. in 20 states from New York to Tennessee and west to Wisconsin. It is most common in the Appalachian region through western Pennsylvania, West Virginia, Virginia, Kentucky, and Tennessee. In Canada, the species is distributed along the north shore of Lake Erie in southwestern Ontario, mainly in Elgin County. A Middlesex County population is apparently extirpated. Less than 1% of the global range is in Canada.

Habitat

Crooked-stem Aster is found on the floodplains of streams and creeks draining into the north shore of Lake Erie. It tends to occur in rich sandy, loamy, or clayey soil, commonly at the edge of woods and usually in partial to full shade. These stands often have a dense layer of graminoids, goldenrods and asters. The species occurs less commonly on roadsides and in old fields. In the U.S., Crooked-stem Aster inhabits moist woods, rocky stream banks, wet fields, and ditches. It often occurs in fairly young or disturbed forest habitat in Wisconsin and Iowa.

Biology

Crooked-stem Aster reproduces both by seed and vegetatively, by means of its elongated rhizomes. In southwestern Ontario, it blooms from late August to early October. Crosses between genetically identical individuals (clones) typically produce little or no seed, indicating that the species is self-incompatible.

Population Sizes and Trends

The total Canadian population size of Crooked-stem Aster is unknown and difficult to estimate because the species forms dense colonies, in which numbers of individual plants are difficult to determine. The number of sites has apparently been relatively stable since 2002. Eleven sites were surveyed and confirmed extant in 2007 or 2010, and another 11 are known from surveys reported in the previous assessment in 2002. The extant sites include three new sites discovered in 2007 and one population not surveyed in 2002 that has been relocated. No sites are known to have been extirpated since 2002, although 11 are not confirmed extant. The index of area of occupancy and extent of occurrence are unchanged since the previous assessment.

Threats and Limiting Factors

Invasive species are probably the greatest threat facing Canadian populations of Crooked-stem Aster, although their impact appears to be limited to date. Invasive species in and near Crooked-stem Aster habitat include Common Reed, Glossy Buckthorn, Garlic Mustard, Reed Canary Grass, Dame's Rocket, and Amur Honeysuckle. Three populations are on road right-of-ways and are potentially threatened by mowing, herbicides, road maintenance and construction. Other populations occur on the floodplains of streams and are potentially threatened by recreational use, logging and livestock grazing. One site is potentially threatened by cottage development. Crooked-stem Aster is self-incompatible, and therefore requires pollination from a genetically distinct, compatible pollen donor in order to achieve full seed set. This could limit its ability to reproduce through seeds and colonize new sites.

Protection, Status, and Ranks

Crooked-stem Aster was assessed by COSEWIC as Special Concern in 2012, and as Threatened in 2002, and is listed on Schedule 1 of the *Species at Risk Act*. As such, it is protected on federal lands through the general prohibitions under SARA. A recovery team has been formed, but a draft recovery strategy is not yet available. In Ontario, the species is listed as Threatened under the *Endangered Species Act, 2007*. The act legally protects individuals of Crooked-stem Aster on all lands in Ontario. It is ranked globally by Nature Serve as apparently secure to secure (G4G5; last reviewed in 1988), nationally as imperiled (N2) in Canada, and as imperiled (S2) in Ontario.

TECHNICAL SUMMARY

Symphyotrichum prenanthoides
Crooked-stem Aster — Aster fausse-prenanthe
Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time *Long-lived perennial species. Seeds can probably germinate and reach maturity within 3 years.*	Unknown 3+ years?
Is there an observed continuing decline in number of mature individuals? *Comprehensive population trend data are unavailable, but more flowering stems were recorded in 2010 than in previous surveys at the four sites where comparable data are available.*	Unknown
Estimated percent of continuing decline in total number of mature individuals within 2 generations	Unknown
Observed percent increase in total number of mature individuals over the last 10 years. *Comprehensive population trend data are unavailable, but more flowering stems were recorded in 2010 than in previous surveys at the four sites where comparable data are available.*	Unknown
Suspected percent increase in total number of mature individuals over the next 10 years	Unknown
Suspected percent increase in total number of mature individuals over any 10 year period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	N/A
Are there extreme fluctuations in number of mature individuals? *The life history of this species, along with observations of the extent of local populations argue against the existence of extreme fluctuations.*	No

Extent and Occupancy Information

Estimated extent of occurrence	1039 km²
Index of area of occupancy (IAO)	76 km²
Is the total population severely fragmented?	No
Number of locations* *Large parts of the distribution are not affected by any threatening event that could rapidly affect all individuals present. Therefore the number of locations is set to the number of subpopulations (i.e. 22 sites) as recommended by IUCN (2011).*	22
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No

* See definition of location

Is there an [observed, inferred, or projected] continuing decline in number of populations? *Although all sites were not revisited as part of this update, all revisited sites remain extant and three new sites were discovered in 2007. No sites are known to have become extirpated in the last 10 years.*	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No
Is there a projected continuing decline in quality of habitat? Invasive plant species are probably degrading habitat	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Number of mature individuals is unknown because of difficulties of counting individuals for this species, which has a clumping, clonal growth form. Table 1 shows that the combined estimate for the number of flowering stems at 7 sites in 2010 exceeds 2100.	
Total	Unknown. Probably 1000s

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	n/a

Threats (actual or imminent, to populations or habitats)

Invasive non-native plant species; roadside mowing and herbicide application; logging, livestock grazing, and recreational use of floodplain habitat.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? *Occurs in 20 states. Common (S5) in OH, PA, and NY, but apparently less common near Lake Erie.*	
Is immigration known or possible? *Seeds are dispersed by wind but the nearest known populations are separated by 80 km across Lake Erie.*	Possible
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Status History

COSEWIC: Designated Special Concern in April 1999. Status re-examined and designated Threatened in May 2002. Status re-examined and designated Special Concern in November 2012.

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:**
Reasons for designation: This perennial aster is restricted in Canada to a small area of the Carolinian forest near the shore of Lake Erie in Ontario. The species has experienced historic declines, but no recent losses have been documented and overall numbers appear to be stable. Invasive plants occur at a number of sites and have the potential to negatively impact the species in the future. Additional threats include indirect impacts of Emerald Ash Borer and roadside maintenance. The species has a restricted distribution in Canada, and its persistence will likely require ongoing monitoring and management of invasive species.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Lack of long-term monitoring at most sites prevents application of the criterion, but population sizes appear to be stable where data are available.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EO and IAO are below the thresholds for Endangered. However, the species is not severely fragmented, occurs in more than 10 locations, and does not undergo extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. The number of mature individuals is unknown, but likely in the 1000s, and no decline has been documented.
Criterion D (Very Small or Restricted Total Population): Not applicable. Estimated number of mature individuals exceeds the thresholds.
Criterion E (Quantitative Analysis): Not met. No quantitative analysis is available.

PREFACE

The Canadian population of Crooked-stem Aster has been relatively stable since the 2002 assessment (COSEWIC 2002). Three new sites were discovered in 2007 and one population not surveyed in COSEWIC (2002), near St. Thomas, Ontario, was relocated. None of the previously known sites are known to have been extirpated since 2002 (although not all were surveyed in 2010). The area of occupancy and extent of occurrence have not changed since 2002, but COSEWIC's criteria have changed, now following IUCN in using an index of area of occupancy based on a 2km x 2km grid square. As a result, the species no longer meets the guidelines for Threatened under the criteria previously used in assessing the species. Habitat quality may have declined with an apparent increase in invasive plant species.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2012)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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Crooked-stem Aster

Symphyotrichum prenanthoides

in Canada

2012

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Symphyotrichum prenanthoides* (Muhl. ex Willd.) Nesom

Common name: Crooked-stem Aster; also Crookedstem Aster (Brouillet *et al.* 2006);

Crooked-stemmed Aster (Semple et al. 1996), Aster fausse-prenanthe.

Synonyms: *Aster prenanthoides* Muhl. ex Willd.
A. floribundus Nutt.
A. prenanthoides var. *longifolius* Porter
A. prenanthoides var. *porrectifolius* Porter
A. prenanthoides Muhl. ex Willd. f. *milwaukeensis* Benke

Family name: Asteraceae, Compositae (Aster Family)

Major plant group: Angiosperm (eudicot flowering plant)

This species has traditionally been treated as *Aster prenanthoides*, but is now treated as *Symphyotrichum prenanthoides* by the Flora of North America (Brouillet et al. 2006). No varieties or subspecies are currently recognized (Semple et al. 1996; Brouillet et al. 2006).

Morphological Description

Crooked-stem Aster is a perennial wildflower up to 90 cm tall with pale blue flower heads and zigzagging stems. It grows in colonies, with multiple stems arising from creeping rhizomes (horizontal underground stems). The leaves become narrowed in the lower third but expand at the base to clasp the stem. Each flower head consists of a yellow disc, surrounded by 17 to 30, pale blue rays.

This species is distinguished from other *Symphyotrichum* by its crooked stems and by the strongly constricted leaves (Figure 1, Figure 2). The flower heads have outer phyllaries (bracts surrounding the flower head) that are usually leaf-like in texture and spreading to reflexed (Figure 3). Crooked-stem Aster is less robust and has smaller flower heads than Purple-stemmed Aster (*S. puniceus*), with which it overlaps in range and habitat, although Crooked-stem Aster prefers somewhat drier sites (Semple et al. 1996). The two species were observed in close proximity during 2010 surveys. A complete technical description is included in Semple et al. (1996).

Figure 1. Crooked-stem Aster. Catfish Creek 2010 (Photo by Allan Harris).

Figure 2. Crooked-stem Aster leaves are strongly constricted above the bases. Catfish Creek, 2010 (Photo by Allan Harris).

Figure 3. Crooked-stem Aster flower head showing the spreading leafy bracts (phyllaries). Big Otter Creek, 2010 (Photo by Allan Harris).

Population Spatial Structure and Variability

Dispersal rates between sites are unknown, but seed dispersal is probably more frequent within a watershed than between watersheds. The maximum distance between the most isolated known site in Canada, at Deer Creek, and its nearest neighbouring site is about 16 km and potentially suitable intervening habitat (wooded creek valleys) is present.

Genetic, morphometric, and meristic data are unavailable for any part of the species' range.

Designatable Units

The Canadian population comprises a single Designatable Unit within the Great Lakes Plains Ecological Area (COSEWIC 2010). All occurrences are in similar habitat types within about 20 km of Lake Erie in the Norfolk and Bothwell sand plains (Chapman and Putnam 1973) and there is no evidence to support segregating populations into distinct DUs.

Special Significance

Canadian populations of Crooked-stem Aster occur in the Carolinian Forest Region at the northern limit of the species' range. They may be genetically distinct from other populations to the south of Lake Erie, which represents a significant barrier to dispersal. The species' ecological significance is unknown. Crooked-stem Aster is poorly known to Canadian botanists and probably has little significance for human use given its rarity, small range, and similarity to other aster species.

DISTRIBUTION

Global Range

Crooked-stem Aster is extant in Ontario and in 20 U.S. states from New York to Tennessee and west to Wisconsin. Its range is apparently discontinuous, with a gap between occurrences in the eastern portion of the range, which extends to southern and eastern Indiana, and the western portion, in northwestern Illinois, Iowa, Minnesota and Wisconsin (Figure 4). In Connecticut and the District of Columbia, the species is known only from historical records (at least 20 years old). Crooked-stem Aster is perhaps most common in the Appalachian region through western Pennsylvania, West Virginia, Virginia, Kentucky, and Tennessee. A disjunct record occurs in eastern Mississippi (Sullivan pers. comm. 2011). Despite reports in the Flora of North America (Brouillet et al. 2006) and NatureServe (2010) there are no verified records of this species in Michigan (Voss 1996; COSEWIC 2002; Reznicek pers. comm. 2011).

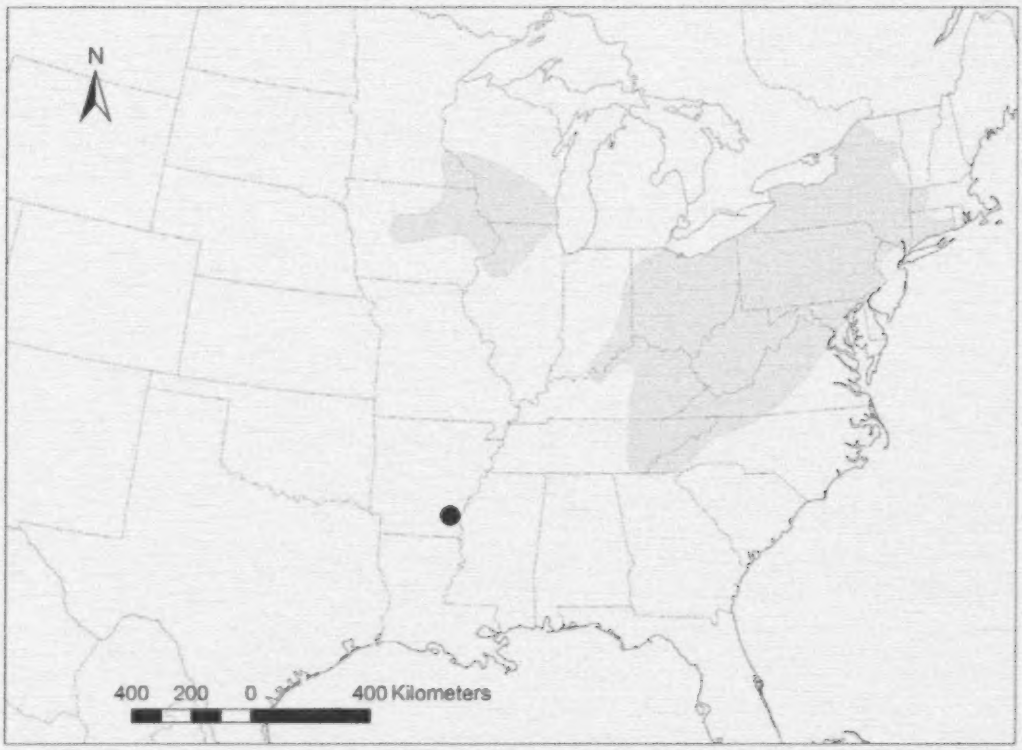

Figure 4. Distribution of Crooked-stem Aster. Non-native occurrence in Florida not shown (from COSEWIC 2002 and NatureServe 2010).

The total global range as measured by minimum convex polygon is approximately 1.7 million km^2 (including the Mississippi record).

Canadian Range

In Canada, this species is confined to southwestern Ontario and is known from Elgin County and one site in Haldimand-Norfolk Regional Municipality. Sites in Oxford and Middlesex counties are apparently extirpated. All Canadian occurrences are within about 20 km of Lake Erie in the Norfolk and Bothwell sand plains (Chapman and Putnam 1973) in the Carolinian Forest Region. Its range extends about 75 km from west to east. Occurrences are associated with Kettle Creek, Big Otter Creek, Catfish Creek, and several smaller streams.

Including all extirpated and presumed extant occurrences, a total of 27 sites for Crooked-stem Aster have been documented in Canada (Table 1). Five of these (1, 9, 12, 22 and 23 in Table 1) were considered extirpated in COSEWIC (2002). Of the remaining 22 sites, eleven were confirmed extant in 2007 and/or 2010 (Table 1). Three of these sites are new discoveries made in 2007 (Table 1). The status of the remaining 11 is unknown (see *Search Effort*; Table 1, Figure 5).

Table 1. Canadian Crooked-stem Aster sites based on COSEWIC 2002, OMNR data (Gould pers. comm. 2011, MacIntyre pers. comm. 2011), and 2010 fieldwork. Site numbers follow the numbering system of COSEWIC (2002). "-" indicates no data. Refer to Table 1 for associated plant species.

Site	Description	Status	# stems 2010	# stems (Observer*; prev. survey)	Notes 2010 (search area / search time)	Land Tenure	Threats
1	Taylor Pond	Extirpated	-	- (WGS 1980)	Considered extirpated in COSEWIC (2002).	Probably Private	-
2	Big Otter Creek	Unknown	-	"Several" (DM; 1985)	Insufficient site information.	Probably Private	Unknown
3	Little Otter Creek Valley Complex, east of Eden	Unknown	-	- (S&Z; 1987)	Insufficient site information.	Probably Private	Unknown
4	Valley of Big Otter Creek, west of Vienna	Unknown	-	50 (S&Z; 1997)	Potential habitat is present along Big Otter Creek.	Probably Private	Unknown
5	Bayham Townline Woods, 5 km east of Vienna	Unknown	-	- (IDM; 1986)	Insufficient site information.	Probably Private	Unknown
6	North of Richmond on Little Jerry Creek	Unknown	-	132 (S&Z;1997)	About 3.5 km of stream valley with riparian forest along Little Jerry Creek.	Private	Unknown
7	Big Otter Creek, north of Calton	Extant	157	- (MJO; 1987)	Most of the plants are found along an old road paralleling the creek through lowland forest, but a few plants also extend up the valley slope into the beech-hemlock forest. (16,400 m^2 / 2 hours)	Private	Invasives: Reed Canary Grass
8	Lake Erie shoreline near Wallacetown	Unknown	-	"Rare" (MJO; 1993)	No plants were observed at this site in 2010 although the habitat is relatively undisturbed. The Lake Erie shoreline is an eroding clay bluff and narrow wave-washed beach with little or no potential habitat. Better habitat is found along the floodplain of an unnamed creek. The lower approximately 500 m of the stream floodplain and 300 m of the Lake Erie shore were searched with no success. (30,260 m^2 / 2 hours)	Private	Invasives: Reed Canary Grass
9	Springwater, Dingman's Ponds	Extirpated	-	- (KY; 1941)	Considered extirpated in COSEWIC (2002). Possibly the same site as 10/11	Catfish Creek Conservation Authority?	-

Site	Description	Status	# stems 2010	# stems (Observer*; prev. survey)	Notes 2010 (search area / search time)	Land Tenure	Threats
10/11 /14	(i) Springwater Conservation Area (north part) (ii) Creek west of Bradley's Creek	Extant	229	- (MJO; 1991) 62 (MJO; 1997)	Roadside. Sites 10, 11 and 14 were treated as separate sites in COSEWIC 2002, but appear to be a single site. Treated as one occurrence in NHIC 2010. (37,414 m^2 / 2 hours)	Catfish Creek Conservation Authority	Invasives: Common Reed, Smooth Brome
12	4.8 km northeast of St. Thomas	Extirpated	-	0 (LEJ; 1952)	Considered extirpated in COSEWIC (2002).	Probably Private	-
13	Lower Silver Creek Valley	Unknown	-	56 (S&Z; 1997)	Suitable stream valley with riparian forest habitat extends about along lower Silver Creek to Lake Erie.	Private	Unknown
15	Tyrconnell	Unknown	-	420 (S&Z; 1997)	Suitable habitat occurs for about 800 m downstream from Lakeview Line to Lake Erie.	Private	Unknown
16	Kettle Creek north of St. Thomas	Extant	34	- (BL; 1994)	On both the north and south sides of the Kettle Creek floodplain. (15,800 m^2 / 2 hours)	Private	Invasives: Reed Canary Grass, Spotted Knapweed
17	Southwest of Straffordville	Unknown	-	- (BL; 1986)	Insufficient site information.	Unknown	Unknown
18	Springwater Conservation Area (south part)	Extant	180	100 (BL; 1986)	Floodplain and adjacent moist seeps. The appendix from COSEWIC (2002) includes a record from about 1 km downstream (Bill Lamond 2630 TRTE), but the site information is imprecise and is included here. (46,117 m^2 / 2.5 hours)	Springwater Conservation Authority	Invasives: Common Reed
19	Northwest of Straffordville	Extant	-	100 (RG; 2007)	OMNR record 2007.	Private	Riverbank is eroding and heavy use of ATVs through area (R. Gould, pers. comm. 2011)
20	Catfish Creek Slope Floodplain Forest ANSI	Unknown	-	"Rare" (BL; 1986)	Collection site unknown.	Probably Private	Unknown
21	Deer Creek Conservation Area	Extant	378	- (DM; 1985)	Found along a 300 m section of the creek valley. Some plants probably missed in the dense floodplain vegetation (5540 m^2 / 2.5 hours). Additional plants were discovered about 1 km downstream from this site in 2011 (Brinker pers. comm. 2011).	Long Point Region Conservation Authority	Invasives: Reed Canary Grass, honeysuckle,
22	3.7 km west-south-west of Komoka Post Office	Extirpated	-	0 (S&Z;1997)	Considered extirpated in COSEWIC (2002).	Private	-
23	Otterville wetland (provincially significant wetland)	Extirpated	-	0 (DM; 1992)	Considered extirpated in COSEWIC (2002).	Private	-

Site	Description	Status	# stems 2010	# stems (Observer*; prev. survey)	Notes 2010 (search area / search time)	Land Tenure	Threats
24	Talbot Creek	Unknown	-	- (DM; 1986)	From the road, there appears to be over 5 km of stream valleys with riparian forest along Talbot Creek.	Private	Unknown
25	Dan E. Patterson Conservation Area and Dalewood Conservation Area	Extant	653	225 (KM; 2004)	Extends along Kettle Creek for about 6.5 m from Dan E. Patterson C.A. to St. Thomas. This site was not included in COSEWIC 2002, but is listed by NHIC (EO#1722). (75,482 m^2/ 4.5 hours)	Kettle Creek Conservation Authority	Invasives: Glossy Buckthorn, Garlic Mustard, Spotted Knapweed, honeysuckle sp.
26	Northeast of Richmond on Big Otter Creek	Extant	644	350 (KM; 2007)	Extends about 400 m along a tributary stream with scattered plants along Big Otter Creek. OMNR records (2007) found additional subpopulations here. (77,665 m^2 / 3.5 hours)	Private	Invasives: Common Reed, Reed Canary Grass, Garlic Mustard
27	East of Eden	Extant	-	12 (RG; 2007)	Road allowance. OMNR survey 2007 (R. Gould pers. comm. 2011).	Private	Mowing, road salting (R. Gould pers. comm. 2011).
28	Duttona Beach	Extant	-	200 (RG; 2007)	Creek bank. OMNR survey 2007 (R. Gould pers. comm. 2011).	Private	Mowing and recreational trail use (R. Gould pers. comm. 2011).
29	Dodd Creek	Extant	-	300 (RG; 2007)	Creek bank. OMNR survey 2007 (R. Gould pers. comm. 2011).	Private	Mowing and additional cottage development proposed (R. Gould pers. comm. 2011).

* BL = B. Lamond; DM = Dave McLeod; IDM = I.D. MacDonald; KM = K. MacIntyre; KY = K. Young; LEJ = L.E. James; MJO = M.J. Oldham; RG = R. Gould; S&Z = Semple and Zhang; WGS= W.G. Stewart

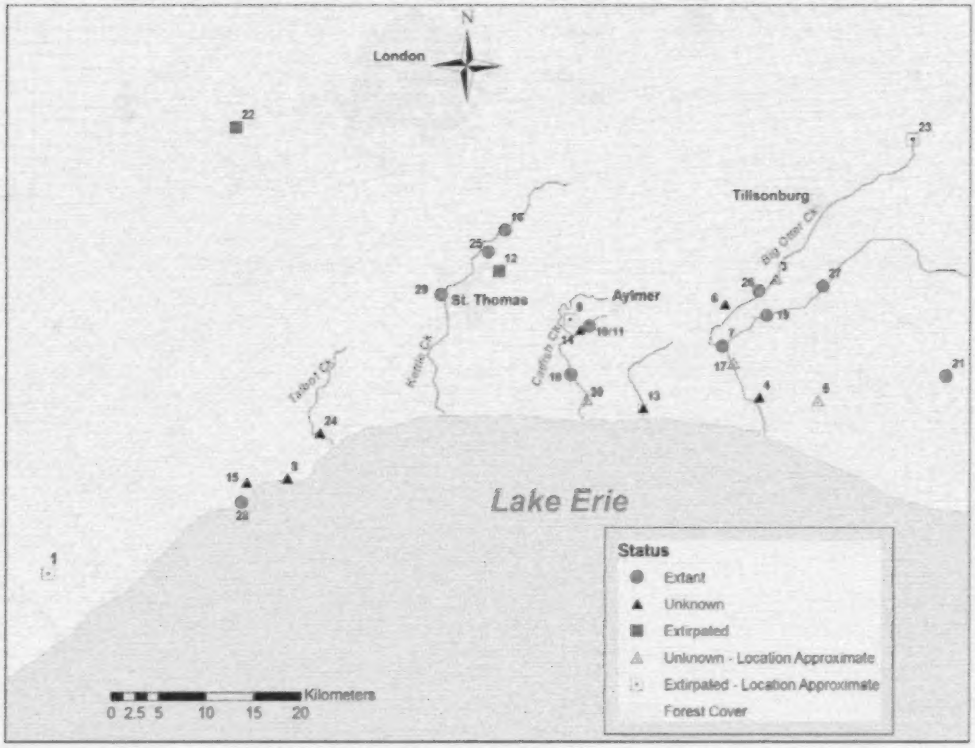

Figure 5. Canadian range of Crooked-stem Aster. Site 2 cited in COSEWIC (2002) is unknown. Refer to Table 1 for details.

Of the total 27 extant, and unknown, and extirpated (prior to 2002) occurrences, 10 are on Big Otter Creek or its tributaries, four are on Kettle Creek or its tributaries, four are on Catfish Creek or its tributaries. South Otter Creek, Deer Creek (a tributary of Big Creek), Talbot Creek, Silver Creek, Dodd Creek, and four small, unnamed creeks near Lake Erie each have a single site. Site 25 (Figure 5) on Kettle Creek near St. Thomas, was not located during COSEWIC (2002) fieldwork, but recent surveys in 2004 by OMNR and in 2010 found plants along about 6.5 km of Kettle Creek.

The extent of occurrence of Crooked-stem Aster in Canada (excluding the five sites extirpated prior to 2002) is 1039 km^2 as measured by minimum convex polygon (including 180 km^2 of Lake Erie). Less than 1% of the global range is in Canada.

The index of area of occupancy in Canada (excluding sites extirpated prior to 2002, but including sites where the status is unknown) is 76 km^2 (as measured with a 2 X 2 km grid).

There is no evidence of a decline in the extent of occurrence or area of occupancy within the last 10 years (although some sites have not been surveyed for more than 10 years), but it must be noted that 11 sites have not been surveyed in the last 10 years.

Search Effort

All known Canadian herbarium records up to 1997 were compiled for the original status report and were examined by J.S. Semple, an authority on *Symphyotrichum* (COSEWIC 2002). The 2002 status report (COSEWIC 2002) reports surveys of four of the sites on September 14–15, 1997. Details of the search effort are provided in COSEWIC (2002).

Ontario Ministry of Natural Resources surveyed sites near St. Thomas in 2004 (MacIntyre pers. comm. 2011) and several sites in 2007 (Gould pers. comm. 2011).

In September 2010, fieldwork was designed to revisit Crooked-stem Aster sites reported in COSEWIC (2002) and Natural Heritage Information Centre (NHIC) (2010) (Table 1). Fieldwork was conducted on September 13 to 17, 2010 by Allan Harris for a total of 42 person-hours. Of the 27 known sites, including all those reported in COSEWIC (2002) and/or NHIC (2010), eight were relocated and searched in 2010, four had counts available from 2007 (and were not revisited in 2010), five were considered extirpated and not revisited in 2010. The remaining ten sites were not revisited because landowner permission could not be obtained and/or because of a lack of sufficient information to relocate the sites. In some cases, observations on habitat quality were made from nearby, even though the sites were not revisited.

Search areas were determined using maps, GPS coordinates, and descriptions from previous fieldwork. Botanical survey effort in Crooked-stem Aster range in Canada has been relatively intensive and the species is fairly distinctive to experienced botanists, therefore it is unlikely that there are large numbers of undiscovered sites, although a small number of additional sites may yet remain undocumented.

HABITAT

Habitat Requirements

In Canada, Crooked-stem Aster is found on the floodplains of streams and creeks draining into the north shore of Lake Erie. It tends to occur in rich sandy, loamy, or clayey soil, commonly at the edge of woods and usually in partial to full shade (Figure 6, Figure 7). Typical habitat is classified as *Moist - Fresh Deciduous Forest* (Ecosite FOD7; Lee et al. 1998) often with Sugar/ Black Maple (*Acer saccharum/ A. nigrum*), ash (*Fraxinus* spp.), and/or White Elm (*Ulmus americana*). These stands often have a dense layer of graminoids, goldenrods (*Solidago* spp.) and asters (*Symphyotrichum* spp.) (Appendix 3). The species occurs less commonly on roadsides and in old fields.

Figure 6. Crooked-stem Aster habitat near Catfish Creek (Photo by Allan Harris).

Figure 7. Crooked-stem Aster habitat at Kettle Creek (Photo by Allan Harris).

Elsewhere in its range, Crooked-stem Aster inhabits moist woods, rocky streambanks, wet fields, and ditches (Brouillet et al. 2006). It often occurs in fairly young or disturbed forest habitat in Wisconsin (Cochrane pers. comm. 2010) and Iowa (Pearson pers. comm. 2010).

Habitat Trends

Forest habitat was presumably lost with clearing associated with European settlement beginning about 200 years ago. The landscape north of Lake Erie originally was about 75% forested (LESPRTT 2008). Presently, the Kettle Creek watershed is about 15% forested (LERSPC 2010a), the Catfish Creek watershed is 16% forested (LERSPC 2010b), and the Big Otter Creek watershed has about 20% forest cover (LESPRTT 2008).

Loss of the floodplain habitat preferred by Crooked-stem Aster may have been less extensive than loss of upland forest. About 40% of the riparian zone of Big Creek remains forested (LESPRTT 2008). Floodplain forest cover is relatively continuous within a watershed, but naturally fragmented between watersheds.

Trends in floodplain forest cover in the last 10 years are unknown, but probably fairly stable because most remaining forest in riparian areas is unsuitable for agriculture or urban encroachment. Regulatory controls for woodlot clearing by conservation authorities have stabilized the loss of forest cover (LERSPC 2010a, b).

In the United States, habitat degradation due to invasive species was cited as a threat to Crooked-stem Aster in Minnesota and Ohio (R. Gardiner pers. comm. 2010, W. Welby Smith pers. comm. 2010). Invasive species of concern in these states include buckthorn (*Rhamnus* spp.), Garlic Mustard (*Alliaria petiolata*), Reed Canary Grass (*Phalaris arundinacea*), Dame's Rocket (*Hesperis matronalis*), Amur Honeysuckle (*Lonicera maackii*), Tatarian Honeysuckle (*L. tatarica*), Common Privet (*Ligustrum vulgare*), Wintercreeper (*Euonymus fortunei*), and Nepalese Browntop (*Microstegium vimineum*). Of these, buckthorn, Garlic Mustard, Reed Canary Grass, Dame's Rocket, and invasive honeysuckle occur at or near some of the Ontario Crooked-stem Aster sites (Table 1), but their impacts on the species are unknown.

BIOLOGY

Life Cycle and Reproduction

Crooked-stem Aster is a long-lived perennial species. In Ontario, it flowers from late August to early October. It is capable of reproducing by seed and asexually by its elongated rhizomes. Although seed production has apparently not been measured, most flowering stems have ten or more flower heads (Harris pers. obs.), each with 39 to 50 disk florets (Brouillet et al.2006), suggesting that each stem can produce several hundred seeds annually. The species is a self-incompatible outbreeding species, as are nearly all asters (Jones 1978). This means that populations usually must have at least two genetically different individuals to produce seed. Pollen transfer between individuals is accomplished by insects, primarily bees (Hymenoptera) and butterflies (Lepidoptera) (COSEWIC 2002). Other insects may also serve as occasional pollen vectors. Details on seed maturation, germination timing, and seed dormancy for Crooked-stem Aster are not documented in the literature.

There is apparently no information on generation time, fecundity, or other reproductive attributes for this species. No hybrids involving this species have been documented (Semple et al. 1996).

Crooked-stem Aster also reproduces asexually by its elongated rhizomes. COSEWIC (2002) estimated between 8 and 28 stems per clone. Observations in 2010 suggest that most (>80%) stems were in flower.

Physiology and Adaptability

The species is typically found in floodplain habitat suggesting that it is tolerant of periodic flooding. Crooked-stem Aster also occurs on roadsides, in old fields, and in young logged forests, indicating that it is tolerant of some human disturbance.

No specific information on propagating Crooked-stem Aster is available. Many asters (including the genus *Symphyotrichum*) are easily grown from seed, and are sold as ornamentals. Seeds can be cold stratified or planted immediately. With all asters, seeds can be stored dry, then cold-moist stratified for a month. However, all aster seeds are short-lived (1-1.5 years maximum) (Cullina 2000; Gartshore, pers. comm. 2009). Stem cuttings collected in late spring will root in water and can be planted out (Cullina 2000; Gartshore, pers. comm. 2009).

Dispersal and Migration

Achene (fruit) dispersal is presumed to be by wind (COSEWIC 2002) and possibly animals. There is no natural disjunction between extant Ontario sites that would severely limit dispersal for an extended period of time. The maximum distance between sites is approximately 16 km with patches of wooded riparian habitat between them. Dispersal of fruits among sites, especially sites that occur along the same creek, is feasible over the long term, but unlikely in any given year.

Canadian populations of Crooked-stem Aster are probably not severely fragmented (IUCN 2011). There is a maximum distance of about 20 km between sites and suitable riparian habitat in the intervening areas. The rate of dispersal of seeds and pollinators along riparian corridors is unknown but probably occurs occasionally.

Interspecific Interactions

Browsing by White-tailed Deer (*Odocoileus virginianus*) was noted at one site (Gould pers. comm. 2011), but herbivory does not appear to be pervasive (Harris pers. obs.).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

In September 2010, a survey was planned based on previously reported Crooked-stem Aster sites (COSEWIC 2002; Natural Heritage Information Centre 2010) (Table 1). Fieldwork was conducted from September 13 to 17, 2010 by Allan Harris for a total of 42 person-hours. Of the 27 known sites, eight were relocated in 2010, five were considered extirpated and not revisited in 2010, landowner permission could not be secured for four, and information was inadequate to relocate ten other sites.

Crooked-stem Aster was at peak flowering on the 2010 survey dates. Surveys were conducted by walking through suitable habitat and counting flowering stems. Initial attempts to estimate number of clones were unsuccessful because the stems were not distributed in discrete patches (clones tend to intergrade into each other) and were usually mixed with a dense tangle of grasses, asters, and other plants. Search areas were determined using maps, GPS coordinates, and descriptions from previous fieldwork. The area and time searched at each site are summarized in Table 1.

Abundance

If each flowering stem is considered to be a mature individual, more than 2100 individuals of Crooked-stem Aster were observed at seven sites in 2010 (Table 1). Additional flowering stems (>500) were counted at three other sites (27, 28, 29, Table 1) in 2007 (these sites were not surveyed in 2010) (Gould pers. comm. 2011). Sites varied from a few flowering stems to hundreds of scattered flowering stems. Eleven sites have not been surveyed for over 10 years and are of unknown status.

The species is clonal and the number of genetically distinct individuals is probably much lower than the number of flowering stems. COSEWIC (2002) estimated between 8 and 28 stems per clone.

Unsurveyed floodplain habitat within the extent of occurrence probably covers 50 to 100 km^2 assuming that about 16% of the land is forested and most of the forested land is in floodplains (LESPRTT 2008; LERSPC 2010a,b). Additional populations may occur within this area, but the species is unlikely to be much more widespread or abundant than currently known (Oldham pers. comm. 2012).

Fluctuations and Trends

The number of known sites presumed to be extant has increased slightly over the last ten years. Three new sites have been discovered since 2002 and the site at St. Thomas is now known to be much more extensive (spanning about 6.5 km of suitable riparian habitat) than previously documented. No sites reported in 2002 are known to have been extirpated (although 11 have not been surveyed since). This species could be overlooked because it is superficially similar to other aster species, and is unlikely to be discovered except by targeted surveys.

Trends in numbers of plants or flowering stems are difficult to assess. COSEWIC (2002) reported that most populations were small, averaging about 20 flowering stems based on herbarium label data and field observations. The 2010 survey discovered much larger numbers of flowering stems (average 325 per site). The apparent increase may actually be due to differences in survey effort, and to the challenges of estimating plant numbers, rather than to population increase.

Crooked-stem Aster is a long-lived perennial species and the adult population size probably does not tend to fluctuate significantly from year to year, in the absence of habitat alteration. Natural processes of erosion and deposition of the floodplain habitat may remove significant numbers of individuals in a short time period, but this has not been documented.

Rescue Effect

The closest extant populations outside Canada are in New York, Pennsylvania, and Ohio, about 80 km across Lake Erie. The species is common (S5) in all three states. Seed dispersal by wind across Lake Erie is conceivable, but unlikely because the species is relatively uncommon in northern Pennsylvania (Grund pers. comm. 2010).

THREATS AND LIMITING FACTORS

The factor(s) involved in the extirpation of the five historical populations are not provided in COSEWIC (2002) but presumably include historical sites that were converted to agricultural or other uses.

Invasive Species

Invasive plant species were observed at eight out of the nine sites surveyed in 2010 (Table 1). Invasive species occurring in and near Crooked-stem Aster microhabitats include Common Reed (*Phragmites australis*), Glossy Buckthorn (*Frangula alnus*), Garlic Mustard, Reed Canary Grass, Dame's Rocket, and invasive honeysuckle (*Lonicera* spp.) (Table 1). None of these species was highly dominant in Crooked-stem Aster habitat. Crooked-stem Aster is a large, vigorous species able to successfully compete with other floodplain species such as goldenrods, other asters, grasses and sedges, suggesting it may be tolerant of modest levels of invasion by non-native species. Negative impacts of invasive plant species on Crooked-stem Aster have been suggested by some experts (e.g. R. Gardiner pers. comm. 2010, W. Smith pers. comm. 2010), but have not been documented in the literature. Potential impacts include allelopathic effects (Garlic Mustard), shading (Glossy Buckthorn, honeysuckle), and altered soil moisture (Common Reed, Reed Canary Grass).

Habitat Loss or Deterioration

Three of the sites (18, 10/11/14, and 28; Table 1) are on road rights-of-way and are potentially threatened by mowing, herbicides, and road maintenance. However, the number of stems at site 10/11/14 (the only site repeatedly monitored) increased between 1997 and 2010 (Table 1) and the species appears to be tolerant of the recent road maintenance practices.

Most populations of Crooked-stem Aster occur on the floodplains of streams and creeks in wooded areas. Such sites are unsuitable for agriculture or residential use and thus not directly threatened by such developments. Recreational use of floodplain habitats does occur and several off-road vehicle trails through Crooked-stem Aster habitat were observed in 2007 and 2010. Although not observed in 2010 (or documented elsewhere) other potential threats include logging and livestock grazing. Proposed cottage development is a potential threat at one site. This species is somewhat tolerant of moderate levels of human disturbance given its presence on road right-of-ways and in old fields in Ontario and its use of ditches and young disturbed forests elsewhere in its range.

Emerald Ash Borer (*Agrilus planipennis*), an invasive beetle first reported in North America in 2002, has killed millions of ash trees in southwestern Ontario and is spreading northward (Canada Food Inspection Agency 2011). No evidence of ash die-back was observed in Crooked-stem Aster habitat in 2010 (Harris pers. obs.), but die-back has occurred east and west of Crooked-stem Aster range on the north shore of Lake Erie. The implications for Crooked-stem Aster are unknown, but could include direct habitat changes such as opening up the canopy in Crooked-stem Aster sites, and indirect effects such as increases in invasive plant species. Crooked-stem Aster occurs in open and partially closed canopy and is at least somewhat tolerant of invasive plants so the impacts are difficult to predict. Emerald Ash Borer has been reported in 16 of 20 states within the U.S. range of Crooked-stem Aster (USDA 2012), but has not yet been identified as a significant threat (Appendix 1). Crooked-stem Aster is a semi-obligate outbreeding species and populations should include several genetically different individuals for full seed set. This could limit the species' ability to colonize new sites.

Other Possible Threats

Other threats related to changes in land use on private lands such as logging and cattle grazing are possible, but not imminent. These lands are protected by floodplain zoning under the *Conservation Authorities Act* (Conservation Ontario 2011) and by the Threatened status of Crooked-stem Aster. The four extant sites in conservation areas are presumably protected from logging, grazing, and development.

Given the restrictions on human development in floodplain habitat and the apparent tolerance of this species to moderate levels of human disturbance, invasive plant species are probably the most serious plausible threat facing Canadian populations of Crooked-stem Aster. The sites have generally similar soil and moisture conditions with no obvious differences in vulnerability to invasive species, and thus all sites are considered potentially impacted by this threat. Nonetheless, invasive plant species have no current impact on Crooked-stem Aster, and the species appears somewhat tolerant of current levels of invasive plants. As a result, the number of locations is set to 22, the number of sites presumed extant, following IUCN guidelines (2011) for situations in which the species is not affected by any threat.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

In Canada, Crooked-stem Aster was assessed by COSEWIC as Special Concern in April 1999. The status was re-examined and designated Threatened in May 2002. Most recently, it was assessed as Special Concern in 2012. The species was included on Schedule 1 of the *Species at Risk Act* (SARA) in 2005. As such, it is protected on federal lands through the general prohibitions under SARA.

Recovery planning has been initiated under the National Recovery Strategy for Carolinian Woodlands Plants by the Carolinian Woodlands Recovery Team, but a Recovery Strategy has not been finalized and critical habitat has not yet been defined.

In Ontario, the species is listed as Threatened under the *Endangered Species Act*, 2007. The act legally protects Crooked-stem Aster on all lands in Ontario.

In the United States, Crooked-stem Aster is officially protected by legislation in Massachusetts where it is designated as Threatened (Appendix 1).

Non-Legal Status and Ranks

Nature Serve (2010) provides the following ranks.

Global Rank: G4G5 (last reviewed in 1988; Nature Serve 2010)
National Rank (Canada): N2
National Rank (US): N3N5

Subnational Ranks (S-ranks) as provided by NatureServe (2010) and updated in Appendix 1 are as follows:

Not Applicable - Exotic (SNA): FL
Possibly extirpated (SH): CT, DC
Critically imperilled (S1): DE, MS
Imperilled (S2): ON, MA, NJ
Vulnerable (S3): IA, MN
Vulnerable? (S3?): NC
Probably secure (S4): IN, IL, WV
Probably secure to secure (S4S5): MD, VA
Secure (S5): KY, NY, OH, PA, TN, WI

For jurisdictions where no rank was provided by NatureServe (2010) (i.e. SU or SNR), a rank was assigned based on consultation with the botanists cited in *Acknowledgements and Authorities Contacted*. Refer to Appendix 1 for details.

The General Status Rank is 1 "At Risk" for Ontario and Canada (Wild Species 2010).

Habitat Protection and Ownership

Four sites are located mainly in conservation areas (Table 1) and receive a measure of protection from some human threats such as logging, woodlot clearing, grazing, and housing development. Recreational use (especially trampling and off-road vehicles) remains a threat in conservation areas. Invasive plant species control is sometimes practised in Conservation Areas (Conservation Ontario 2011), but its efficacy is unknown.

The remaining sites are on private land, but Crooked-stem Aster populations in floodplains (the majority of known sites) are protected in areas designated as "hazard lands" (i.e., floodplains). Conservation authorities regulate construction, filling, and grading in floodplains; however, logging, cattle grazing, and recreational uses are permitted without being subject to regulation.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Allan Harris is a biologist with over 20 years' experience in northern Ontario. He has a B.Sc. in Wildlife Biology from the University of Guelph and a M.Sc. in Biology from Lakehead University. After spending seven years as a biologist with Ontario Ministry of Natural Resources, he co-founded Northern Bioscience, an ecological consulting company based in Thunder Bay, Ontario. Al has authored or coauthored dozens of scientific papers, technical reports, and popular articles, including COSEWIC status reports for Gibson's Big Sand Tiger Beetle, Bogbean Buckmoth, Rapids Clubtail, Laura's Clubtail, Northern Barrens Tiger Beetle, Small-flowered Lipocarpha, and Drooping Trillium. Al also authored the Ontario provincial status report for woodland caribou, and has authored or coauthored national and provincial recovery strategies for vascular plants and birds. He is a member of the Committee on the Status of Species at Risk in Ontario (2008 - 2012).

Robert Foster is co-founder and principal of Northern Bioscience, an ecological consulting firm offering professional consulting services supporting ecosystem management, planning, and research. Dr. Foster has a B.Sc. in Biology from Lakehead University and a D. Phil in Zoology from the University of Oxford and has worked as an ecologist in Ontario for over 15 years. Rob has authored or coauthored COSEWIC status reports on the Gibson's Big Sand Tiger Beetle, Bogbean Buckmoth, Laura's Clubtail, Rapids Clubtail, Northern Barrens Tiger Beetle, Bluehearts, and Drooping Trillium, as well as recovery plans for rare plants, lichens, and odonates.

COLLECTIONS EXAMINED

Collections were examined as part of the previous assessment (COSEWIC 2002), but were not consulted as part of this update.

Appendix 1. Subnational ranks for Crooked-stem Aster in North America (NatureServe 2010).

Province / State	S-Rank	Notes
Ontario	S2	
Connecticut	SH	5 historic specimens from New London and Fairfield counties (1 from Hartford county is possibly cultivated) (McAvoy pers. comm. 2010)
Delaware	S1	2 extant populations. Both in riverine habitat on the floodplain of a river in the Piedmont province of the state (Zyko pers. comm. 2010)
D.C.	SH*	Listed by Shetler and Orli (2000) as occurring in DC. A single 1914 record in Smithsonian (2011). Unranked in NatureServe (2010)
Florida	SNA	Not native to Florida (NatureServe 2011).
Iowa	S3	Rare to infrequent in the eastern 2/3 of the state, occurring in wooded ravines and moist, disturbed woods (Pearson pers. comm. 2010)
Illinois	S4*	Not tracked (Mankowski, pers. comm. 2010). NatureServe ranking is SU.
Indiana	S4*	Fairly common, especially in the southeastern part of the state. Principal habitat is stream banks, especially those with rock substrate (typically limestone) (Homoya pers. comm. 2010). NatureServe ranking is SNR.
Kentucky	S5	No recent change in status. Wet fields and swamps (Littlefield pers. comm. 2010).
Massachusetts	S2	Bordering on S3. 15-21 populations. Most populations are between 100-1000 plants. Listed as Threatened, but considering downgrading to Special Concern (Connolly pers. comm. 2010).
Maryland	S4S5*	Common (S4S5). Particularly common on the shales and sandstones of western counties but may be found in every county except perhaps east of the Chesapeake Bay (Frye pers. comm. 2010). NatureServe ranking is SNR.
Michigan		No verified records of this species in Michigan (COSEWIC 2002; Reznicek pers. comm. 2011; Voss 1996). Michigan reports are based on a mislabeled specimen by O.A. Farwell from the Keweenaw Peninsula. Listings by NatureServe (2010) (SNR) and Flora of North America (2006) are in error.
Minnesota	S3*	Fairly rare and limited to reasonably high-quality forests in a few southeastern counties. Probably qualifies as S3. Threatened by habitat loss and degradation (primarily from invasive species such as buckthorn and garlic mustard). Populations trends unknown, but probably downward (Smith pers. comm. 2010). Unranked in NatureServe (2010)
Mississippi	S1*	One documented population in the Tombigbee National Forest in Winston County. The rank may be changed to S1, due to the evident extreme rarity in the state (Sullivan pers. comm. 2011). NatureServe ranking is SNR.
New Jersey	S2	
New York	S5	Widely distributed across all regions, except Long Island (Ring pers. comm. 2010). "Swamps, wet ditches, thickets, stream banks and gravel bars, and seepage areas. Usually in wet to wet-mesic soil or soils that are seasonally wet. Often with some amount of canopy cover although most robust in open sites" (New York Flora Association 2011).

Province / State	S-Rank	Notes
North Carolina	S3?	Occurs in about 15 counties mountainous western part of the state (Flora of the Southeast 2011).
Ohio	S5*	Common in floodplains, stream terraces, and other low woods. S-rank would be S5. Threats are invasive plants such as *Alliaria petiolata, Phalaris arundinacea, Hesperis matronalis, Lonicera maackii, Ligustrum vulgare, Euonymus fortunei,* and *Microstegium vimineum* (Gardiner pers. comm. 2010). NatureServe ranking is SNR.
Pennsylvania	S5*	Very common, especially in the western part of the state and the piedmont. Less common in the Ridge and Valley region. Several specimens from the very narrow zone in the Lake Erie watershed. Recently ranked as S5. Perhaps underrepresented in collections (Grund pers. comm. 2010). NatureServe ranking is SNR.
Tennessee	S5*	Known from 9 counties in East Tennessee and 1 in Middle Tennessee (Crabtree pers. comm. 2010). Moist forested floodplains and lower slopes. Secure and should not be considered rare at any level (Estes pers. comm. 2010). NatureServe ranking is SNR.
Virginia	S4S5	About 35 counties in the Ridge and Valley area on the north and west side of the state (Flora of the Southeast 2011).
West Virginia	S4	Collected in all but nine of 55 counties, and probably occurs in those nine as well. Not tracked. Woods, low places and along streams (Harmon pers. comm. 2010).
Wisconsin	S5*	Collections from 29 counties. Beech-maple forests, floodplain forests, and cold wet forests with overstorey of *Fraxinus nigra, Thuja occidentalis,* and *Populus* spp. Often near springs and streams. Often in fairly young or disturbed habitat. (Anderson pers. comm. 2010; Cochrane pers. comm. 2010).

* ranked SU or SNR by NatureServe (2010). Tentative rank is based on opinion of the authorities cited.

Appendix 2. Vegetation Data in Crooked-stem Aster Habitat, September 2010.

The following vegetation data were collected between September 13 and 17, 2010 by Allan Harris. Quadrats were centred on Crooked-stem Aster plants where the population was most dense at each site. A single quadrat was completed at each site. Quadrat size was 5 m X 5 m. Percent cover was estimated for (i) all vascular plant species occurring at greater than 1% cover, (ii) all woody species, and (iii) all non-native vascular plant species.

Vegetation layer codes are as follows:

Layer 2 = > 10 m tall
Layer 3 = 2 to 10 m tall
Layer 4 = 0.5 to 2 m tall
Layer 5 = < 0.5 m tall
Layer 6 = herb and graminoid

Non-native species are indicated *.

Species	LAYER	% Cover				
		Site 18	Site 26	Site 21	Site 25	Site 16
Acer negundo	2				50	
Acer nigrum / saccharum	3			60		
Acer nigrum / saccharum	4	2			5	
Agrimonia sp.	6			1		
Ambrosia trifida	6	10				
Amphicarpaea bracteata	6	1	2			
Aquilegia canadensis	6	0.1				
* *Arctium minus*	6				0.1	3
Arisaema triphyllum	6			0.1		
Bidens sp.	6	2				
Carex sp.	6	2		70*		5
Carpinus caroliniana	4			10		
* *Centaurea maculosa*	6				0.1	1
* *Cirsium arvense*	6					0.1
Cornus alternifolia	3	70				
Crataegus sp.	3			30		
Cystopteris bulbifera	6			2		
Elymus virginicus	6	6	2		1	
Epilobium coloratum	6					1

Species	LAYER	% Cover				
		Site 18	Site 26	Site 21	Site 25	Site 16
Equisetum pratense	6	8	10			
Eupatorium maculatum	6			30		
Eupatorium rugosa	6	3		1		
Euthamia graminifolia	6					1
Fraxinus pennsylvanica?	2	60				
Fraxinus pennsylvanica?	4			1		
Fraxinus pennsylvanica?	5		1			
Galium asprellum	6		0.1	0.1		
Geum sp.	6			1		
* *Glechoma hederacea*	6				3	
Glyceria grandis	6	4				20
Grass sp	6		0.1			
Helianthus sp.	6	3				
Impatiens capensis	6					0.1
Laportea canadensis	6			35		
* *Lonicera tatarica*	3				4	
* *Lysimachia nummularia*	6				2	
Maianthemum racemosum	6	0.1				
Mitella nuda	6		0.1			0.1
* *Phalaris arundinacea*	6					60
* *Phragmites australis*	6		1			
Pilea pumila	6				0.1	5
* *Plantago major*	6				0.1	
Poa palustris?	6		3			
Poa sp.	6					6
Polygonum scandens	6				0.1	
Populus balsamifera	2			40		
Rhus radicans	5			0.1		
Rhus typhina	3	4				
Ribes americanum	5		1			
Rubus sp.	4	2			30	
Sanicula sp.	6			0.1		
Scirpus atrovirens?	6	2				
Solidago canadensis	6			3		

Species	LAYER	% Cover				
		Site 18	Site 26	Site 21	Site 25	Site 16
Solidago gigantea	6	50	10		4	
Symphyotrichum cordifolium	6					1
Symphyotrichum lateriflorum	6				1	3
Symphyotrichum prenanthoides	6	2	30	25	6	2
Thalictrum dioicum	6				3	
* *Tussilago farfara*	6	5	80			
Ulmus americanus	2		40			
Viburnum lentago	3			4		
Viola sp.	6	1		0.1	0.1	
Vitis riparia	5				1	
Xanthium strumarium	56				0.1	0.1